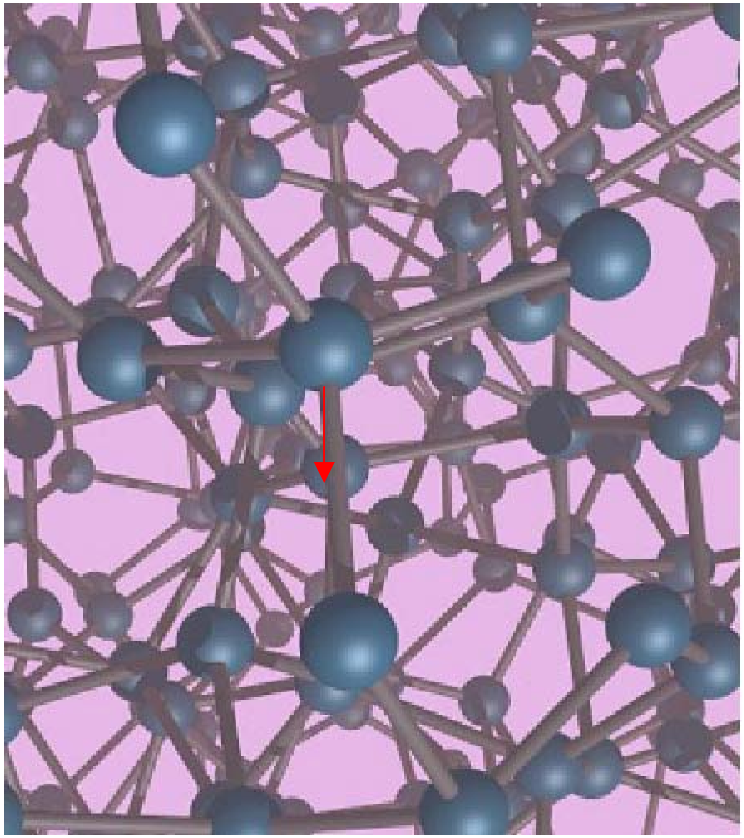
# Metastable Defects in Amorphous Semiconductors

## P. Craig Taylor, University of Utah, DMR-20073004

The Staebler-Wronski effect in amorphous silicon alloyed with hydrogen has been known for over 25 years. In this effect exposure to light creates defects that limit the performance of thin-film transistors and solar cells. The defects are silicon atoms with three bonds to neighbors instead of the usual four (so called "dangling bond"). We have discovered a second amorphous semiconductor, germanium alloyed with hydrogen, which displays the Staebler-Wronski effect. This discovery is important because it provides a second system in which to understand, and ultimately to eliminate, this deleterious effect. Elimination of the Staebler-Wronski effect will remove the most important impediment to better electronic devices for a wide class of semiconductors.



Structure of amorphous silicon or germanium. Red arrow indicates missing, or dangling, bond when neighboring silicon atom is not present.

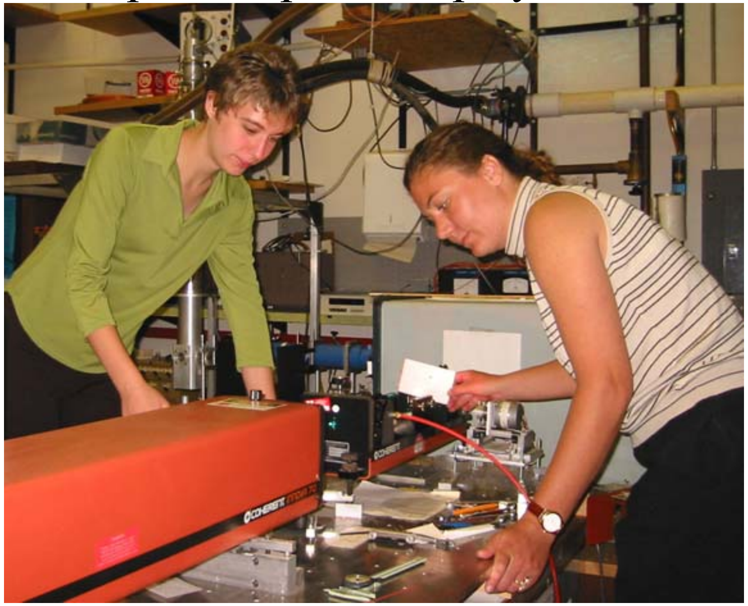
An semiconductor is a solid in which the resistance to the flow of electrical current can be varied dramatically. This property makes semiconductors the basis for all modern electronic devices, such as computers. An amorphous semiconductor is a solid in which the atoms have a well defined number of nearest neighbor atoms as dictated by chemistry but in which there is no long range order as exists in a crystalline solid. The picture shows an amorphous structure where the blue balls represent the silicon atoms and the sticks represent the chemical bonds between the atoms. Amorphous silicon containing about 10 atomic % of hydrogen is the prototypical amorphous semiconductor because its chemical composition is simple (just silicon and hydrogen) and it is useful in a wide variety of electronic applications. Each silicon atom has four nearest neighbor atoms (either silicon or hydrogen) as dictated by its chemical valance. When there is an atom missing so that the silicon has only three neighbors the site acts as a defect, which degrades the electrical properties that are important in electronic devices. Furthermore, in amorphous silicon these defects are generated either by passing an electrical current through the solid or by shining light on the solid. The generation of these deleterious defects is known as the Staebler-Wronski effect. In the last three years we have published two contributions in Physical Review Letters that have furthered our understanding of this effect in amorphous silicon. Our most recent result concerns the observation of the Staebler-Wronski effect in amorphous germanium. This observation is very important because it provides a second chemical element in which to test our understanding of the Staebler-Wronski effect, and therefore eventually to eliminate this effect.

# Metastable Defects in Amorphous Semiconductors

## P. Craig Taylor, University of Utah, DMR-20073004

**Education:**
Six undergraduates (Jeremy Conlin, Christina Derbidge, Elizabeth Heider, Christie MacDonald, Russell Nagle, and Robin Plachy), five graduate students (Eungho Ahn, Chris Nelson, Jared Olson, Janica Whitaker, and Wei Xu), and one postdoctoral research associate (Tining Su) contributed to this work. Plachy received a Kennicott Scholarship and a Goldwater Scholarship. Heider and Plachy are now in graduate school. Ahn, Nelson and Whitaker have received their Ph.D. degrees and are currently employed elsewhere as postdoctoral associates.

**Societal Impact:**
Elimination of the Staebler-Wronski effect will lead to larger, faster, and cheaper flat-panel displays.



Undergraduate student, Robin Plachy (left), and graduate student, Janica Whitaker (right), preparing for laser irradiation of an amorphous semiconductor.